EEL 5666

Intelligent Machines Design Laboratory

Spring 2005

Written Report 1

μCHIP

Micro-Controlled High-tech Independent Putter

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Date: 1/25/2005

Table of Contents:

Introduction

The goal of this project is to design and develop a robot that plays miniature golf (or a sufficiently simplified version of miniature golf) autonomously. The robot will be able to perform four different functions: (1) It will locate and approach a golf ball that has been randomly placed near it, (2) determine the direction of the hole and turn to face that direction, (3) compute the distance to the hole, and (4) drive toward the ball and strike it with the appropriate force necessary to sink the putt. The robot I will develop to accomplish this task will be called μCHIP (Micro-Controlled High-tech Independent Putter), or simply CHIP, combining a term common both to golf and electronics.

Integrated System

The brains of the system will be the ATmega128 microcontroller from Atmel. This is what the robot will use to process incoming data from its sensors, make decisions, and issue commands to its actuators. Movement will be accomplished using two DC gear motors to power the two drive wheels, with a caster wheel at the rear to provide stability. CHIP will use bump sensors (mechanical switches) and infrared (IR) sensors to detect and avoid any obstacles or walls he encounters while navigating the green. He will use a color digital camera module to locate the ball and find both the direction and the distance to the hole. In addition, he may also include other sensors such as ultrasonic transducers (sonar) or an RF transmitter or receiver depending on what is ultimately needed to accomplish the task. The entire system will be powered by rechargeable 12V batteries.

Mobile Platform

The chassis will consist of at least one platform on which all the components will be mounted as compactly as possible. The main design consideration for the structure of this chassis is that I would like to be able to position CHIP with the ball directly between the two drive wheels. This would enable him to find and approach the ball directly and then spin in place around the ball (driving the motors in opposite directions) to face the hole. This will be a much simpler way to line up the shot than having to drive around the ball to approach it from the right angle. To accomplish this, the platform will either be cut away in the front or raised above the height of a golf ball so as not to interfere with the ball during this process. There will also be a striking surface directly behind and between the drive wheels with which to strike the ball.

Actuation

The combination of drive motors and drive wheels will be chosen such that CHIP will be able to drive at a sufficient speed to hit the ball the maximum required distance to the hole. This will be determined by deciding what the maximum distance will be (depends on setup of putting green, see Experimental Layout), determining the speed necessary to hit the ball that distance over the artificial turf surface, estimating the torque required to move the predicted mass of the robot at that speed given the estimated friction due to the caster wheel and the motor bearings, and, of course, adding a generous safety factor. The only other actuation will be the servo(s) used to change the angle of the camera.

Sensors

The robot will use a variety of sensors to collect data from its environment in order to make the right decisions and accomplish its goal.

Bump Sensors:

On the front of the robot, there will be two mechanical switches with extended wire actuators positioned so that they will be activated first if CHIP gets too close to an object. When one of the switches is activated, the microcontroller will immediately send the appropriate signals to the drive motors to cause the robot to stop, back away from the object, and turn away from it before continuing its task.

Infrared Sensor:

CHIP will also be equipped with an IR proximity sensor that will be used in conjunction with the bump sensors to avoid obstacles and also help with general navigation. The Sharp GP2D02 can measure distances from 10 to 80 cm by using a linear CCD array to determine the angle of the reflected IR light, and using triangulation to calculate the distance of the object (see Fig. 1). This information will be used to identify potential obstacles in advance and steer around them. It can also be used in conjunction with the camera to determine the nature of an object (ie. size, distance).

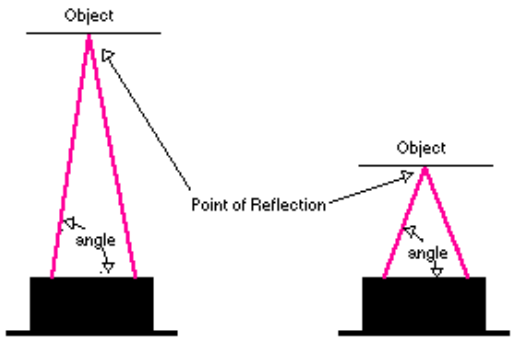

Figure 1 (www.acroname.com/robotics/info/articles/sharp/sharp.html)

Camera sensor:

The most complex sensor that CHIP will use is the CMOS camera module, the CMUcam. This module consists of an Omnivision OV6620 single-chip CMOS CIF color digital camera with a 4.0mm, F2.8 lens and IR filter, along with image processing hardware and software that can perform various functions. CHIP will be able to use it to determine the position (x-y) and size of objects of a specified color (ie. the ball, and a large orange ball mounted on the pole). The camera will be mounted on a servo so that the microcontroller can aim it at any vertical angle.

Behaviors

CHIP's overall task is to strike a golf ball in the right direction and with the right speed so that it drops into the hole. He will locate a ball placed near him with the camera, turn to face it, and drive towards it, all the while avoiding any obstacles in his path. The camera on its servo will follow the ball until it is located directly between the drive wheels. Once CHIP is positioned over the ball, he will use the camera to look for the orange ball that indicates the hole, and turn the drive wheels in opposite directions to spin in place and line up the putt, while keeping the ball in position. The camera will be able to determine the distance to the hole by computing the size of the orange ball. CHIP will back away from the ball and then drive towards it and strike it with the appropriate speed (using pulse-width modulation to drive the motors) necessary to sink the putt.

Experimental Layout

There are several experiments that I will need to perform in order to have CHIP interpret the data from his sensors correctly. For starters, I will need to experimentally determine how fast to drive the motors to putt the ball a given distance. To do this, I will first need to establish the green surface (turf) and construct the robot platform and drive wheel assemblies. I will also need to experiment with the CMUcam to determine how small an object it can recognize (ie. How far away the ball and hole can be). As far as the setup of the putting green, I will probably use a slightly raised cone (like a volcano) for the hole instead of building a portable raised plywood surface in order to have a real hole. This will also keep the ball from getting too close to the hole on a miss, so CHIP won't have to worry about avoiding the hole when doing a follow-up putt.

Conclusion

To be written…